ON THE BIOLOGY AND EARLY STAGES OF *HELICOBIA AUSTRALIS* (SARCOPHAGINAE), A DIPTEROUS INSECT ASSOCIATED WITH GRASSHOPPERS.

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(Five Text-figures.)

[Read 29th June, 1938.]

Most of the following observations were made on *Helicobia* bred in culture in the laboratory, the original flies having been obtained from Mr. A. L. Tonnoir's grasshopper field-cages. These comprised five females and two males which emerged between 4th and 6th November, 1936, from cages containing *Austroicetes pusilla*. At the end of April, 1937, they had reached the seventh generation, and numbered many thousands. The first generation was bred in a small field-cage, the flies being provided with dates, water and liver. During December it was found that they could develop normally and more rapidly in the laboratory, so the culture was moved indoors.

The flies were active, flying rapidly about the cage, and feeding freely from the dates and sugar provided. They mated frequently, from the first day of emergence and at any time of the day. The females deposited their larvae on the liver, and the larvae were reared on meat through each generation.

Life Cycle, Longevity and Fecundity.

The shortest period between the emergence of the female and the first deposition of larvae was six days. The feeding period of the larva was three to four days, and the pupal period usually ten days. In the small laboratory cages, during the three summer months (maximum temperature ranging from 68 to 87°F.), the period from adult to adult was twenty-three days. The average length of the life cycle for the seven generations reared was thirty days.

A pair of flies of the third generation was isolated in a small cage. Six days after emergence the first batch of maggots was deposited, and five other batches were subsequently produced. Counting only flies or puparia, without considering mortality amongst the larvae, the total progeny was 133, giving an average of 22 maggots to each batch. The first three batches were much larger than the later ones. Before the last batch of maggots was deposited, flies had emerged from the first batch and produced larvae. Of the relatively few larvae deposited in each batch, a proportion usually succumbs, either from desiccation after hatching or from failure to escape from the membranous chorion. Two females were dissected, one six days and one seven days after emergence. The first contained a few maggots and many well developed embryos, and the second contained sixty-seven maggots.

From the beginning of autumn onwards a large proportion of puparia failed to produce flies, whereas previously practically one hundred per cent. had done so. Dissection showed healthy nymphs but little developed. At this stage cages

were transferred to a constant temperature room (22°C.), where development continued without interruption until early in May. The puparia of the last generation formed in middle May remained in that stage for three to four months, indicating that hibernation is coincident with a diapause. Since larvae pupate readily, whether at high or low temperatures, it is obvious that *Helicobia* passes the winter in the pupal stage, not, as in many Calliphorinae, as a prepupa.

Early in April the Chalcid, *Mormoniella vitripennis*, entered one of the cages of sixth generation flies and a large proportion of the puparia were parasitized.

Larviposition Preferences and Larval Food.

The female prefers moist under-surfaces, holes or crevices in the medium for larviposition, and meat in a decomposed state is preferred to fresh meat. When the flies were offered the choice of meat and dead grasshoppers (including *Chortoicetes terminifera*, *Austroicetes pusilla*, *Gastrimargus musicus* and *Phaulacridium vittatum*), they showed a decided preference for the meat. After three hours maggots were present on the meat and none on the hoppers. After one day the meat was full of maggots and only one hopper had two maggots on it. The flies prefer a fresh mouse carcase to freshly-killed grasshoppers, the maggots being placed in the mouth and eyes in the same manner as *Calliphora augur*. When dead grasshoppers only were provided, several maggots were deposited on each, being placed in any position, but most frequently under the base of the hind leg. Some of the dead hoppers had a number of small shrivelled maggots attached to them, and one large living maggot inside. Meat or dead grasshoppers were preferred to live grasshoppers, in which the flies never showed any interest. Live hoppers of various species, including those listed above, and in all stages of development, were provided both in field and laboratory cages. They were removed at frequent intervals, examined and dissected, but none contained *Helicobia* larvae. When meat was provided in these cages larvae were deposited on it, when no meat was provided the larvae were deposited on dead grasshoppers, and when hoppers were removed as soon as dead, no larvae were produced.

Larval Food:

1.—A freshly-killed large grasshopper and small mouse of approximately the same size were each split and six *Helicobia* placed in each. Two days later only one maggot was alive in the grasshopper and was found inside the head. There were four large maggots in the mouse. All five larvae pupated. A skinned mouse put into a cage of flies had many maggots deposited on it, and these grew rapidly to a large size. It is interesting to note that the flies bred in the cultures on meat are generally larger than wild flies, which apparently breed in dead grasshoppers only.

2.—One *Helicobia* larva was put under the base of the hind leg of each of three dead grasshoppers. Only one of these larvae survived.

3.—One *Helicobia* larva was placed on each of six immature live grasshoppers, either under the scutellum, base of the hind leg, or on the spiracle. Two days later three of the hoppers were killed and dissected, but revealed no trace of the larvae. The other three were kept for some weeks and allowed to grow, and then killed and dissected, but no maggots were found. It thus appears that, not only will the female flies refuse to larviposit on live grasshoppers, but larvae are unable to develop on them.

4.—It was observed many times that larvae of the same age on meat and on dead hoppers were different in size. Unless the hoppers dried up rapidly the

feeding stage was of the same duration in both, but fully-fed larvae on hoppers were never as large as those on meat.

5.—The only instance in which *Helicobia* larvae were found in the field was when the bait pan of a trap, set for four days with dead hoppers and water, contained *Helicobia* and *Calliphora augur* maggots.

Sheep Strike: Newly-deposited larvae were placed on a sheep in the insectary, the wool being moistened. On examining the sheep 18 hours later a typical strike was found to have developed. Forty-nine hours after being placed on the sheep the maggots were full-fed and exceptionally large, and had produced a brown, irritated patch on the skin 2 inches long by 1 inch wide, although they were scattered in the wool all round. The maggots were removed, allowed to pupate, and all produced flies.

Helicobia in Blowfly Traps.

It was observed during general blowfly trapping that a few *Helicobia* were frequently caught in carrion-baited traps. The following experiments were then carried out to find if it is attracted to specific baits.

1.—A glass trap was set in the field, using dead grasshoppers as bait. After four days thirteen *Helicobia*, comprising 7% of the total flies, were caught.

2.—Two traps were set for four days.—*A*, baited with dead hoppers, caught 27 *Helicobia*, equalling 45% of the total catch; *B*, baited with a dead rat, caught 3 *Helicobia*, equalling 2% of the total.

3.—Three traps were set for two days.—*A*, baited with dead hoppers, caught 5 *Helicobia* = 35%; *B*, baited with a dead rat, caught 4 *Helicobia* = 3%; *C*, baited with dead snails, caught 4 *Helicobia* = 2%.

These experiments were carried out in February. During February and March a few *Helicobia* were caught in most of the glass traps set for other purposes. They were attracted to liver, small carcases, snails and worms, whether untreated or sprinkled with borax. At the end of March they were also caught in large Western Australian traps baited with liver.

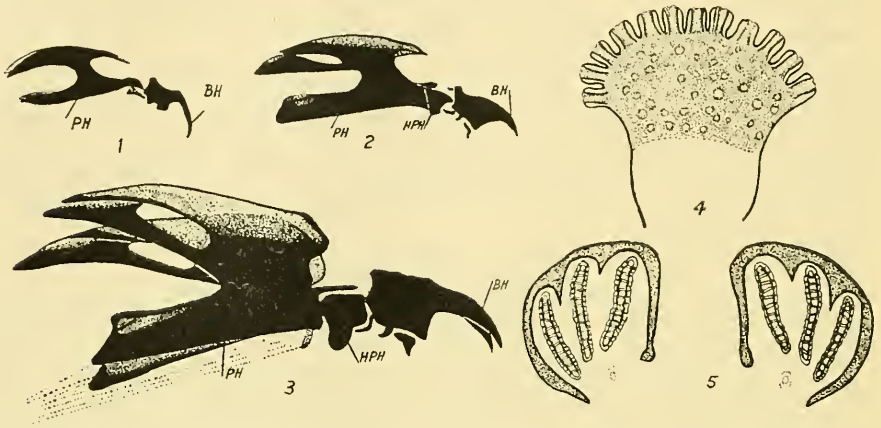
First Stage Larva.

Larvae taken from the ovaries of the female, or as they are deposited, measure from 2 to 2½ mm. in length. They are white and semi-transparent, showing the bucco-pharyngeal armature extending the length of the thoracic segments. The two head-lobes are distinct, each with antenna and maxillary palp. The antenna consists of a small round swelling with a short finger-like segment in the centre. The maxillary palp is a flat disc with a number of minute sensillae arising from it.

The larva is a typical maggot shape, with each segment bounded by an annulation made of several rows of tiny setae. The setae are most strongly developed ventrally where they appear as broad-based spines, and become weaker dorsally, appearing as fine hairs. They are directed backwards, except on the dorsum, where they point forwards. The fifth, sixth and seventh segments have the dorsal setae most strongly developed. The spines are almost colourless to light brown in colour. The first thoracic segment has the anterior border particularly heavily spined ventrally, the spines being strong and almost black and directed forwards. The posterior spiracles are situated at the bottom of the typical Sarcophagid spiracular hollow on the eighth abdominal segment. The lobes of the invagination are fringed with fine setae. The tracheal trunks end in a felt chamber and a pair of slits, these being visible through the skin dorsally.

The bucco-pharyngeal armature (Text-fig. 1) consists of a basal pharyngeal sclerite and the pair of oral hooks. The dorsal thecal arch of the pharyngeal

sclerite projects forwards into a long point. The buccal hooks are slender, sharply pointed, and unusually long in comparison with the length of the pharyngeal sclerite.



Text-figs. 1-5.—*Helicobia australis*.—Buccopharyngeal armature of larva. 1, First stage; 2, Second stage; 3, Third stage, × 65—*bh*, buccal hooks, *ph*, pharyngeal sclerite, *hph*, hypopharyngeal sclerite; 4, Anterior spiracle, × 170; 5, Posterior spiracles, × 100.

Second Stage Larva.

In this stage the larva is 3½ to 6 mm. long. It is white and opaque, although the bucco-pharyngeal armature may still be discerned through the thorax. The dorsal surface has the segmental bands spread out widely over the surface, so that a large part is spinose, but the spines are minute, flat and light coloured, being less conspicuous than in the first instar. The spines have a broad scale-like base with a very short point. They are most developed on the ventral surface. As in the first stage, there is a ventral arch of strong spines at the fore-border of the first thoracic segment. The head and antenna are similar in structure to the first stage. The spiracular hollow is dorsal, deep and with a wide oval aperture. The margin is marked by several rows of minute brown spines. The spiracles have two slits in each plate, the slits having the characteristic slope of Sarcophagids. The anterior spiracles are similar to those in the third-stage larva, and have the same number of processes. On each side of the anus is a large papilla projecting laterally, these being posterior to the spiracular hollow. The bucco-pharyngeal armature (Text-fig. 2) has, in addition to the pharyngeal sclerite and buccal hooks of the first instar, a hypopharyngeal sclerite connecting the two. The hooks are shorter and broader and a pair of small dental sclerites are present near their base.

Third Stage Larva.

The length is from 6½ to 13 mm., those measuring 12 or 13 mm. being full-grown. Some maggots were found to be in the third instar two days after deposition in January, so the earlier instars are very brief in summer. The larva is of a typical maggot form, with a pointed anterior and truncated posterior end. It is white, with the segmentation very indistinct owing to the small spines usually confined to segmental annuli being spread over the whole surface. The bilobed head is similar to that in the second stage larva, but the antenna and palp are

slightly chitinized, appearing as yellow dots. The antenna has a short cylindrical segment and a small finger-like apical segment. The oral grooves are well-developed in this instar.

Each thoracic segment has a wide band, consisting of about 12 rows of spines, at the fore-border. The rest of the segment is smooth, except for the presence of a few spines dorsally on the third. The first segment is unusually short. The abdominal segments, with the exception of a few small areas, are covered with small flat colourless scales with minute spines pointing backwards. In the posterior fourth, scales point forwards from third to seventh segments of abdomen. The centre of each segment is smooth ventrally, except the eighth, and there is a narrow intersegmental membrane which is without scales. Ventrally each segment has a pair of large rounded swellings on each side of the mid-line. On the smooth ventral area between the swellings and in the centre of each abdominal segment in a transverse series are six small slightly raised oval tubercles with invaginated centres. Laterally there are one or two, and dorsally eight to ten, of these small mounds, but the dorsal and lateral ones are not as prominent as the ventral. They are devoid of spines.

On the eighth segment the only smooth areas are a small patch between the spiracular hollow and the anus, the extreme tip of the anal papillae, a narrow strip below the anus, and the inside of the spiracular hollow. There are three pairs of small papillae both on the upper and lower margins of this hollow which is a wide oval in shape. Around its margin the small spines of the integument are particularly dense and acutely pointed. The anus is prominent, with a pair of large lateral papillae, which are spiny except at the tip.

The anterior spiracles (Text-fig. 4) project prominently from the dorso-lateral surface of the first thoracic segment near the posterior margin. They are orange-coloured and bear twelve to fourteen processes. The posterior spiracles (Text-fig. 5) lie in the deep invagination of the eighth abdominal segment and are also orange-coloured. The plates are separated by about half the spiracular width. They have the typical Sarcophagid form, with a gap in the peritreme near the button and the slits sloping in the characteristic fashion.

The bucco-pharyngeal armature (Text-fig. 3) consists of the pharyngeal sclerite, with divided dorsal cornu of Sarcophagid, the hypopharyngeal sclerite and the buccal hooks, with the small dental sclerites and hypopharyngeal plates. The structure of these component parts is very characteristic for all Calliphoridae examined and illustrated by other workers. The armature in *Helicobia* is of the usual type, without any distinctive or unusual features, and almost identical with those illustrated for species of *Sarcophaga*. The interesting feature lies in the fact that the pharynx is definitely ridged, indicating that the larva is saprophagous rather than parasitic (Keilin, 1924).

The Puparium.

The puparium from a well-grown larva measures 7 to 8 mm. in length and 3 to 4 mm. at its greatest width. The colour changes from a bright reddish-brown to dark brown with age. It is rotund and convex all round, with the appearance of a small *Sarcophaga* puparium. At the posterior end is the usual deep concavity of all *Sarcophaga* puparia. The surface shows the spines of the third-stage larva flattened and blunted. The anterior spiracles of the larva project out in front of the puparium at the anterior end. There is no trace of external breathing horns. The pupa has a pair of spiracles on the thorax, but apparently these never break through the shell of the puparium.

Discussion.

Noble (1936) bred *Helicobia australis* from grasshoppers collected at Burren Junction, and recorded it as a parasite. It has also been found occasionally in the grasshopper cages at Canberra, but there is no evidence that it developed in living hoppers. The observations recorded in this paper show that this species is not a parasite, but develops normally in dead hoppers. It probably breeds also in other dead insects, in the same manner as species of *Sarcophaga*, and possibly also in the carcases of small native mammals. Cuthbertson (1935) records *H. monroi* Curran from Rhodesia breeding in faeces and bodies of dead locusts.

The larva of no species of *Helicobia* has been previously described. Although it is closely related to *Sarcophaga*, the mouth parts and spiracles being similar in both, there are definite features which distinguish *Helicobia* from any other Sarcophagid. The integumental spines in all *Sarcophaga* larvae, including *S. depressa* bred from dead grasshoppers, are more or less limited to the segmental bands and the prominences, but *Helicobia* is almost uniformly spinose. Also, *Helicobia* has a thinner integument than is usual in *Sarcophaga*, and has the ventral and lateral protuberances less developed. The most spinose species of *Sarcophaga* larva described is that of *S. cistudinis* Ald. (Knipling, 1937), a parasite of tortoises. *Helicobia*, however, is more completely spinose than this species, and is also distinguished from it by the prominent tubercles on the eighth abdominal segment, these being greatly reduced in *S. cistudinis*.

The puparia of *Helicobia* and *Sarcophaga* are very similar, except in size. Cuthbertson described the puparium of *H. monroi*. In general shape and size it resembles that of *H. australis*. Specimens which Mr. Cuthbertson kindly forwarded were dissected and some knowledge of the larva thus gained. Evidently *H. monroi* has the integumental spines confined to the segmental bands as in *Sarcophaga*. It differs also from *H. australis* in having short inconspicuous anterior spiracles with only six processes. The posterior end with its spiracular cavity and tubercles is similar in both, as is also the bucco-pharyngeal armature, except that the oral hooks are shorter and broader in *H. monroi*. There is, however, no reason in the early stages to warrant separating them generically.

References.

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